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ORIGINAL RESEARCH ARTICLE

A literature synthesis of personalised technology-enhanced learning: what works and why

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Personalised learning, having seen both surges and declines in popularity over the past few decades, is once again enjoying a resurgence. Examples include digital resources tailored to a particular learner's needs, or individual feedback on a student's assessed work. In addition, personalised technology-enhanced learning (TEL) now seems to be attracting interest from philanthropists and venture capitalists indicating a new level of enthusiasm for the area and a potential growth industry. However, these industries may be driven by profit rather than pedagogy, and hence it is vital these new developments are informed by relevant, evidence-based research. For many people, personalised learning is an ambiguous and even loaded term that promises much but does not always deliver. This paper provides an in-depth and critical review and synthesis of how personalisation has been represented in the literature since 2000, with a particular focus on TEL. We examine the reasons why personalised learning can be beneficial and examine how TEL can contribute to this. We also unpack how personalisation can contribute to more effective learning. Lastly, we examine the limitations of personalised learning and discuss the potential impacts on wider stakeholders.

Keywords: personalisation; personalised learning; effective learning; review; synthesis; evidence-based research; technology-enhanced learning; personalised education; individual learning; adaptive learning

Introduction

Personalisation occurs when some product, service or resource has an element of individualised adjustment, such that we receive a different experience, based upon information about us as end users. It is intended as a positive experience, so we are introduced to products/services we are most interested in or are most relevant to us, to save having to find it ourselves or filter it out from a large number of competing products or services (Brown *et al.* 2006). An oft-cited example is the recommender system on the Amazon retail website: we are typically shown other products we may be interested in, based on our past shopping history or that of others who have bought or viewed the same product as us.

For learners, personalisation means adjusting the learning experience, for example, by showing the learner resources based on age, ability, prior knowledge or personal relevance or giving adaptive quizzes that get harder as more questions are answered correctly (FitzGerald *et al.* 2017). It is intended to address a 'one-size-fits-all' approach

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that may disadvantage learners, and can provide tailored support dependent on our engagement with online course materials and peer interaction. The idea is that we should be taught on an individualised basis that addresses the differences between us (Green *et al.* 2005). However, while the idea of personalisation might be appealing, the reality of its implementation is much more complex. Selwyn (2016) argues that in many schools, personalised learning has been reduced to the presentation of the same content in a different sequence for different students. Perrotta and Williamson (2018) point out that the algorithms behind learning analytics that drive personalisation are politically and economically dependent and in some cases might exacerbate rather than reduce educational inequality.

We aimed to address the conflicting rhetoric surrounding personalised technology-enhanced learning (TEL) and through a synthesis and critical review of literature, identify the potential benefits and mechanisms of effective personalised TEL. The significance of our paper is twofold. Firstly, with an increasing number of venture capitalists and large multinationals such as Google now investing in this area, there are concerns of re-appropriation of pedagogical designs/principles for their own purposes – potentially led by profit rather than pedagogy (Kucirkova and FitzGerald 2015). Our work might inform new developments in these areas. Secondly, large increases in UK university tuition fees in recent years have led to students demanding value for money and personalised learning/support could help boost student satisfaction scores (Neves and Hillman 2017). It could also help improve student retention (Adams Becker *et al.* 2017), which can be an issue at all levels of education, including in low-cost/‘free’, non-formal courses such as MOOCs (Massive Open Online Courses) (Jordan 2015). Like many learners, those studying MOOCs (and many other online learning platforms) tend to have different backgrounds and motivations, but with the additional challenge of being highly geographically dispersed. However, initial work by Sunar *et al.* (2015) has suggested that current MOOC pedagogical designs do not address these individual characteristics effectively. We expand Sunar *et al.*’s work to examine TEL as a whole, as not every online learner is studying a MOOC. We also examine published work from further back in time, to analyse literature from ‘pre-MOOC’ times. Our second major contribution therefore is the identification and characterisation of effective personalised TEL and learning, which has not been done before.

The paper is driven by the following overarching research questions:

RQ1 – What are the potential benefits of technology-enhanced personalised learning in secondary and higher education?

RQ2 – How can technology-enhanced personalisation contribute to *effective* learning and teaching?

Defining personalised learning

Personalised learning is not a new phenomenon; indeed, some would argue that all learning needs to be personalised for learners to engage with it (Beetham 2005). Effective teachers know that they often need to explain things differently to different learners, based on those learners’ current knowledge and understanding of the world. Differentiated learning materials or ‘streaming’ of school pupils into learning sets based on ability are examples of other established approaches.

However, learners of all ages now have increased opportunities to access learning materials, particularly online, and may already be creating their own personalised

learning environments or experiences. This may be part of a formal, managed learning experience, at a school, college or university, or it may not. Indeed, a FutureLab report noted that a young person's digital learning resources may already offer a large degree of personalisation that is not recognised or understood by 'their formal school experiences' (Green *et al.* 2005, p. 3).

This notion of personalisation taking place within formal contexts is one of three issues that arise when considering personalisation and TEL. Firstly, personalisation has become a politicised field in recent years, particularly in the United Kingdom (Jones and McLean 2018). There are many references to government speeches or reports, which may have introduced their own biases and perspectives into an already complex societal and academic issue. This paper refers to a range of publications reflecting work carried out in this field, including government reports, although we are clear in pointing out where there may be issues of quality or rigour, as this may have implications for practice.

Secondly, much of the published literature related to personalised learning focuses on learners in compulsory education rather than further/higher education, or informal/incidental or lifelong learning, thus potentially ignoring a large sector of learners.

Lastly, many publications scarcely mention technology as a means of achieving personalisation, instead focusing more broadly on face-to-face teaching and direct interaction with and between teachers, pupils, parents and other stakeholders.

Personal versus personalised?

Jones *et al.* (2013) examined the role of technology in the Personal Inquiry (PI) project to support both *personal* (qualities or characteristics relating to an individual person) and *personalised* learning (how resources are deployed that might relate to those qualities). They propose three key aspects to personalised learning: *choice*; *personal relevance*; and *learner responsibility*. Underwood *et al.* (2007) also state how content choice is frequently used to personalise the learning experience and that learner responsibility (through goal-setting and self-monitoring) is also desirable but less commonly seen in compulsory education.

This paper focuses specifically on *personalisation*, that is, the ways in which learning can be utilised, based upon particular characteristics of relevance or importance to learners. We also consider the critical issue of *control* – that is, who or what is making decisions about the personalisation mechanism and how the influence of these decisions might be changed, updated or mitigated. Control is strongly linked to the notion of choice and is a core aspect of any personalised system, yet can be easily overlooked, particularly by those who favour a more technical or systematic/top-down solution. Self-directed learning, which relates strongly to an individual's approach to learning and elements of control, has also been investigated in relation to personalised learning (see e.g. Kim *et al.* 2014).

Methodology

The review is a qualitative synthesis of published studies, discussed in relation to their key themes and contributions. In mining the literature, we followed the principles of a systematic review in that we methodically reviewed published literature (particularly, but not restricted to, peer-reviewed journal articles) in relation to a set of keywords and scored the articles on predetermined inclusion/exclusion criteria. We used the

terms ‘personalised education’ or ‘personalised learning’ or ‘individual learning’ or ‘adaptive learning’ to search databases relevant to education and TEL, looking for the number of published articles utilising these key words from 01 January 2000 to 31 December 2017 in four major databases: Google Scholar, Web of Knowledge, IEEE and ERIC. This resulted in the number of articles found below from the following databases:

From Table 1, it can be seen that these search terms produced a large number of publications for consideration. Even though we limited the search to TEL/educational technology disciplines and electronic learning, there were some papers that were not directly relevant to the keywords used. In addition, some searches did not allow the necessary combination of keyword searching, publication format and date range. The final search generated 107 publications, which were recorded and downloaded. The decision whether each publication should be included in this review was based on the following inclusion criteria, which have been identified and highlighted already in this paper as pertinent issues:

- 1. the inclusion of the word personalisation within the article
- 2. with a focus on learners in secondary or higher education (i.e. aged 11 years+)...
- 3. ...who were engaged in formal, informal or non-formal education
- 4. the publications were dated between the years 2000 and 2017
- 5. the study needed to be in English.

Table 1. Numbers of papers resulting from databases including the search terms highlighted above.

	Google Scholar	ISI Web of Knowledge ¹	IEEE Xplore ²	ERIC ³
2000	0	7	No data	0
2001	0	4	No data	0
2002	0	4	No data	0
2003	1	7	8	0
2004	0	11	0	7
2005	0	11	8	7
2006	0	11	20	5
2007	0	12	17	10
2008	0	21	1	5
2009	1	20	4	15
2010	0	13	11	17
2011	0	12	1	18
2012	2	17	10	22
2013	1	19	0	16
2014	1	25	10	14
2015	2	15	1	14
2016	7	26	0	15
2017	3	6	4	7
totals	18	241	95	172

¹Filtering to appropriate domain, that is, social science.
²Search limited to TEL/educational technology disciplines, that is, ICALT conferences and IEEE TLT journal.
³Search limited to ‘electronic learning’ descriptor to prevent unrelated disciplines further reducing the accuracy and representation of articles relevant to the search.

Publications were excluded if they:

1. had a broader perspective of education with little focus or detail about personalised learning and/or the role of TEL to enact this
2. referred to aspects of personalisation not relevant to TEL.

As a result of this second search, we arrived at a subset of 50 publications and conducted a thematic review (Braun and Clarke 2006) in order to answer our two research questions. Publications were categorised as to which research questions they helped to answer, and an iterative, grounded approach (Glaser and Strauss 1967) was used to elicit thematic codes (a bottom-up, inductive approach). The authors used a team approach, first of all working independently and then coming together to discuss and refine the themes. These themes were grouped into common clusters, and then a deductive (top-down) approach was used to double-check these clusters against those papers, to ensure there were no missing themes or codes. All reviewed articles are included in the paper and the full list is contained in the References section; articles that were not gleaned from the systematic review are marked with an asterisk.

We now report on how the literature attempts to characterise personalised learning.

Characteristics of personalised learning

We have teased out how others have defined personalisation in terms of learning in general before looking at the implications of this for TEL systems. We consider both *what* can be personalised, and also *how*.

In 2004, and with a focus on compulsory education, the UK government's DfES (Department for Education and Skills) proposed five aspects to personalised learning:

1. *Assessment for learning* and the use of evidence and dialogue to identify every pupil's learning needs
2. *Teaching and learning strategies* that develop the competence and confidence of every learner by actively engaging and stretching them
3. *Curriculum entitlement and choice* that delivers breadth of study, personal relevance and flexible learning pathways through the system
4. *A student-centred approach to school organisation*, with school leaders and teachers thinking creatively about how to support high quality teaching and learning
5. *Strong partnership beyond the school* to drive forward progress in the classroom, to remove barriers to learning and to support pupil well-being. (Pollard and James, 2004, p. 5)

These five components were amplified further by Hargreaves who identified nine 'gateways' through which personalisation might happen (Hargreaves 2004; National College for School Leadership 2005). These include assessment for learning; learning to learn; student voice; new technologies; curriculum; advice and guidance; mentoring and coaching; workforce development; and also school organisation and design. In comparison, the FutureLab Learner's Charter, aimed at provoking discussions of how institutional change and digital technologies may enable personalisation, focuses on four key areas: feedback (assessment and recognition); choices (i.e. learner voice and choice); skills and knowledge (curriculum) and learning environment (pedagogies and institutions) (Green *et al.* 2005).

These aspects strongly relate to the *what* of personalisation – that is, what can be personalised, in terms of teaching and learning activities. There are clearly some areas of overlap, with commonalities found around *assessment; choice; teaching and learning strategies; self-development* (including skills and knowledge – primarily of learners/teachers but may also refer to other key stakeholders such as parents); use of *personal characteristics/personal data; educational content and organisation* (both physical – of the institution – and electronic – of resources).

Now, having considered *what* can be personalised, we move onto the *why*: why should learning be personalised – what benefits can it offer, and to whom?

Potential benefits of personalised learning

We can answer our first research question from three levels: that of the learner (micro), teacher (meso) and institution (macro), although there is inevitably some overlap between them. The examples below showcase explicit benefits gleaned from the literature and will be discussed further in the next section where we examine *effective learning*.

Benefits to individual learners (micro level)

Studies have suggested that personalisation can increase motivation (Jones *et al.* 2013), learner empowerment (or the perception thereof) and improve attitudes to learning (Higgins *et al.* 2008). Brown *et al.* (2006) also found that university students preferred using a personalised VLE (virtual learning environment) for exam revision over other, non-personalised methods and felt it was more desirable than a ‘one-size-fits-all’ solution, suggesting again that learner motivation and perceptions may signify important benefits when implementing personalised learning. It is also worth noting, however, that student satisfaction scores do not necessarily correlate with student academic performance (Rienties and Toetenel 2016).

Järvelä (2006) also agrees that student interest and motivation can be increased by personalised learning, especially where students are given opportunities to inspire their creativity and curiosity. She highlights the opportunity for personalised learning to contribute towards sharing and developing expertise, through collaboration and networking. She also mentions the potential for personalisation to contribute to better results, through a student’s personal development of better learning strategies, skills (including social and collaborative learning) and technological capacities. She suggests how personalisation can cater for differences in learning contexts and cultures, referring to examples of sociocultural practices in urban versus remote rural areas.

Kinash (2014) proposes that personalisation at the university level could better prepare students for future careers, as they could tailor their curriculum and learning design to suit particular job markets, some of which may be fast-moving and may change during the time they spend studying for their degree. This notion of co-created curricula through student participation (student voice) is not new but is gaining traction in a number of schools and universities across the world, particularly in the higher education sector (Bovill 2013). It is also a way for students to engage in meta-learning, which we discuss in more detail later in the paper.

A problem long associated with formal education relates to start dates, that is, when school terms and university courses start. Paludan suggests that personalisation

could help solve problems relating to the time of year and age at which children start school, where some children may be disadvantaged by being the youngest in their year (Crawford, Dearden, and Meghir 2007; Paludan 2006). A more personalised commencement of formal learning could also help in terms of moving away from fixed timetables or dates/timings of examinations, which could help students complete university courses quicker, reduce tuition fees and progress into employment sooner (Seldon 2014). However, the cost of this may be prohibitive, with educational institutions having to provide additional staffing throughout the year, or other resources in order to supply this level of service.

Benefits to teachers (meso level)

Some teachers perceive ICT/technological solutions as being linked to personalisation much more strongly at secondary education than at primary level (Underwood *et al.* 2007). However, the focus on secondary schooling may be because disengagement can be more of a problem at this age than at primary level and personalisation is seen as a way of addressing this (2020 Review Group 2006).

Personalisation can also support teachers via learner feedback, some of which can be automated so that teachers can focus on more high-level commentary. There has been much promise shown in some of the published studies from learning analytics and personalised learning support (Broadfoot *et al.* 2013; Drover 2015). However, some studies of systems incorporating such techniques and showing improved learner engagement and more effective learning have been published by the systems developers (e.g. McGraw-Hill LearnSmart 2011) and hence may be subject to a lack of objectivity and independence.

Benefits to the institution (macro level)

The 2020 Vision report highlights the importance of personalisation in helping to tackle underachievement in education and raising standards in compulsory education (2020 Review Group 2006). It suggests that, in addition to not engaging pupils effectively, many schools do not provide them with the necessary skills and that *personalisation is a matter of moral purpose and social justice* (2020 Review Group 2006, p.7).

There may be some financial benefit to personalisation, from efficiency savings of asking students to use their own electronic devices, to the use of shared learning objects available to students online from *large reservoirs of content* (Martinez 2002, p.24). However, many would dispute these prospective efficiency savings, instead stating that the opposite is true: that personalisation is actually more costly (de Freitas and Yapp 2005). This is revisited later in this paper (see 'limitations' section).

The characteristics identified and discussed so far relate to learning in general, and not specifically to TEL. Very little has been published on the characteristics of personalisation in TEL, which tends to explore more about *how* – that is, how to enact personalised learning through technology/computer-assisted learning. However, it is clear that TEL can provide personalised learning through a variety of different mechanisms. Guidance proposed by Martinez (2002) includes five mechanisms, which we expanded in our previous work (FitzGerald *et al.* 2017). We suggested a framework for modelling different dimensions of personalisation in TEL that includes: what might be personalised; learner characteristics; the type of learning where personalisation

occurs; who/what is doing the personalisation; how is it carried out; and the key stakeholders/beneficiaries (FitzGerald *et al.* 2017). This framework serves as a valuable resource in order to change or consolidate existing practice. It also suggests design guidelines for effective implementations of future personalised TEL and therefore guided our interpretation of the literature in relation to our second research question.

Personalised learning and links to effective teaching and learning

Our second research question considers how personalisation can contribute to effective teaching and learning. In interpreting effective learning, we draw upon work by Watkins *et al.* (2002) who define it as

- a constructive activity
- carried out with others
- steered by the learner's actions.

They state that

effective learning is all of these at their best, PLUS the monitoring and review of whether approaches and strategies are proving effective for the particular goals and context. An effective learner is versatile and can actively utilize different strategies and approaches for different contexts and purposes.... (Watkins *et al.*, 2002, emphasis ours)

Watkins *et al.* consider effectiveness from three different aspects: learner effectiveness; teacher effectiveness and also meta-learning (learning about learning, i.e. metacognition). Technology-enhanced personalisation can be enacted throughout all these three aspects, as described below.

Learner effectiveness

Learner activity, engaged in either individually or jointly, can be personalised through offering links to learning opportunities and curricula that relate to students' informal interests or broader learning goals, potentially through a computer-aided, personalised needs-benefit analysis (Laurillard 2005). Wider curriculum provision – and, crucially, learner choice – may be possible through creating technology-enhanced partnerships with other providers, and through using online tutors and resources (e.g. Open Educational Resources, or OERs). Well-designed e-learning resources can adapt to the learner's needs, much more than is possible in non-TEL settings (Laurillard 2005). Learner agency can be supported through personalised modes of study, such as mixing face-to-face and online learning; part-time or full-time; and potentially at different online start times. Blended learning and adaptive, interactive learning environments can lead to learning 'on the go' where learners can use mobile devices to provide seamless or continuous contexts for learning, and the line between formal and informal learning can become more blurred, according to the learner's preferences and goals (Sharples 2013). Different forms of assessment can provide feedback to the learner about their learning, and online systems can provide assistance, guidance and advice adapted to their current position to empower learners with

the information needed to take the next steps in their learning journeys (Kingsbury, Freeman, and Nesterak 2014). Technology-enhanced personal learning environments enable dynamic adaptation of content to match instructional objectives (either by the system, based on rich and flexible learner models, or by the learners themselves) which would also support the development of a learner's *online learning ability* (Martinez 2002, p. 25).

Teacher effectiveness

Watkins *et al.* (2002) state that teacher activities tend to focus around tasks, resources, time and pacing, social structure and role. Personalised, formative learner feedback, increasingly available through learning analytics solutions, can help teachers to focus on higher-level support and commentary. Assessments could be made available when learners – or teachers – feel that they are ready for them, and can suggest next steps to be taken by the learner, leading to personalised recommendations to support learner trajectories based on their stated goals (Laurillard 2005). Teachers can also act as facilitators to, and curators of, online resources to guide learners to high-quality materials, and by doing so can also help foster networks of learners and promote linkages with other learners (who may themselves also be other teachers) (Chen, Chen, and Tsai 2009). Here, we see how personalised TEL can lead to a change in the role of the teacher from the traditional 'instructor' to that of a learning enabler. This means learners can become more active, creative and reflective and hence one of the critical aspects of personalised TEL is encouraging change in how some practitioners currently work (Laurillard 2005). New modes of assessment mentioned above could also take account of a larger range of abilities and other intellectual strengths, in order to help motivate students further (Järvelä 2006). However, it is also important to realise that for many teachers, the time required to engage in new schemes or training is very limited, in roles that are already overstretched, and this will be a difficult barrier to overcome. In addition, personalised recommendation systems can sideline teachers' roles and position them as librarians, curators and monitors instead of listeners, co-learners and mentors (Kucirkova and Cremin 2017).

Meta-learning

Personalised TEL can make the entry into learning more engaging, interactive and personally relevant, whether the learners are relatively young or mature students with a professional career behind them (Laurillard 2005). By encouraging learners to consider why and how they want to learn, we are engaging them in conversations about learning how to learn; a personalised digital plan could then be used by learners to log their learning goals and provide motivation for future reflections on their activities (Kim *et al.* 2014). Going forward, e-portfolios and shared online progress files (with input from teachers and/or caregivers if relevant) can aid reflection and review of learner progress, supplemented with data and feedback from both assessment system, and learning analytics dashboards. Becoming part of a wider learner network will also help individuals develop meaningful relationships with peers and teachers online, promote peer learning and support the changing role of the teacher as learner too (Laurillard 2005; Watkins *et al.* 2002). However, such interventions need to be managed carefully, as engaging learners in metacognitive

tasks can lead to reduced performance and affect their attitude to learning (Loizidou and Koutselini 2007)

Criticisms and limitations of personalised learning in TEL

Personalised TEL is not without its difficulties. One challenge is how to support learners in keeping track of, and integrating, different learning activities carried out in different places, at different times and with different technologies (Järvelä 2006; Jones *et al.* 2013). The PI project led by Jones *et al.* (2013) examined how technology-supported scientific inquiry could become more motivating and meaningful to students by asking them to investigate topics of personal relevance to them. It addressed the issue of asynchronous learning contexts by developing the nQuire toolkit: software implemented on and accessed from mobile devices which learners could use in and across different inquiry contexts (Jones *et al.* 2013).

There are many criticisms relating to the use of cognitive-based personalisation, such as those seen in ITS (Intelligent Tutoring Systems) or AEH (Adaptive Educational Hypermedia) (see e.g. Brown *et al.* 2009). These criticisms include classifying learners on a dichotomous scale, the system having too much control and not enough adaptation to accommodate changes in learner understanding (particularly student-driven learning and knowledge acquisition occurring outside of those systems). Cognitive-based personalisation also suffers from theoretically flawed pedagogical or psychological models that underpin much published work. One example is learning styles, which have poor internal validity and reliability and are now widely discredited by most educational researchers (see also Coffield *et al.* 2004; Kirschner and van Merriënboer 2013). Categorising learners based on cognitive preferences suggests that these learners may find it difficult to learn in ways that are not matched with those preferences (Bailey 2004; Guldborg 2004). However, where a learner starts and how they progress in their learning – their learning trajectory – may have little or no resemblance to how their cognitive preferences have been captured at a single point in time. Some learners show early promise which doesn't transfer to their later learning, while some may be 'slow burners' who take time to develop their academic skills and strategies, which result in them becoming better learners (Bailey 2004).

Personalised learning has not always been shown to improve learner performance, especially for students in high-performing schools or institutions, and productive learning does not always require personalisation (Underwood *et al.* 2007). Personalisation can also be expensive, both from financial and time/resourcing perspectives (Conlan, Dagger, and Wade 2002), as learning materials may have to be authored and presented in multiple different ways to accommodate different learner models. This seems counter-intuitive to the aforementioned economic benefits. We suggest that the costs may well be expensive under current methods of personalisation but as Open Educational Resources (OERs) become more widespread and universally accepted, there may be opportunities, through application of learning design, to make some efficiency savings in the longer term.

We also need to consider who has control over personalisation. We need to consider questions such as 'Is students' learning personal or personalised?' How much is students' own contribution and control of learning embedded in the final product? Is such personalisation adaptive (so it can change dynamically to suit changing contexts or learner states) or adapted (more fixed and less flexible)? Customisable

(by the learner) or customised (by the teacher, ‘the system’, or other external entity)? Who is the active agent when learners are provided with a personalised learning experience? There is still much debate over who has control (or who should) and under what circumstances.

Much of the literature talks about how learning must be made personally relevant in order to be most effective. We often look at learning as being a deeply personal and individual phenomenon, albeit one that is shaped by many external resources, people and places. This is exemplified best with self-regulated learners, and suggests that personalisation is something that should take place in direct negotiation with the learners themselves. The 2020 Vision report supports this idea: technology facilitates personalised learning by enabling students to choose what they learn and when, thus blurring the line between formal and informal learning, giving rise to ‘anywhere, anytime’ learning, enhanced by the provision of software to be used at home where necessary (2020 Review Group 2006). However, Campbell *et al.* (2007) are keen to point out that, at least in compulsory education, learners currently have very little control over their curriculum (as evidenced in part by the PI project) and assessment of their work is determined by others, such as teachers or even the state itself. They also state that learner autonomy, where permissible, tends to only reward self-motivation, and not promote the self-regulation of students. Hartley agrees, arguing that personalisation has little to do with child-centred pedagogies and suggesting that the theoretical basis of personalisation comes from marketing theory rather than any fundamental educational paradigm (Hartley 2009).

Lastly, the ‘choice-personalisation paradox’ described by de Freitas (2005) relates strongly to both cost and learner control. The sheer mass of online resources available to learners presents the problem of how to find high-quality materials without spending too much time and effort doing so; hence, the *range* of choice presented to learners may be prioritised, rather than the quality or depth of such content. Filtering of this content (by teachers, or an ‘intelligent’ system) provides one solution; however, this takes away control from the learner. Hence, we have a critical paradox where personalised TEL might actually result in reduced learner control, less choice and/or lower quality resources, the complete opposite of what was originally intended.

Implications for stakeholders and future challenges

If personalised learning is to happen – especially in a technology-enabled context – there will need to be buy-in from many different stakeholders, not least of all from the educators who will be involved in its deployment (Yapp 2005). Paludan (2006) suggests that some teachers with fixed ways of working may find this difficult and may not want to engage, especially if they have been teaching for many years.

In addition, external factors may limit what can be achieved. Both Jones *et al.* (2013) and Underwood *et al.* (2007; 2009) highlighted the difficulties in applying personalised learning within a strictly controlled curriculum, which very much constrains what content and assessment learners can engage with. Furthermore, Underwood *et al.* (2009) identified the need for synergy of investment and opportunity, within four nested educational spaces (school/institution, teaching space, personal learning space and living space) in order to create effective conditions in which personalised learning could occur. These investments and opportunities may be difficult to come by given that educational institutions are often stable and resistant to change.

That said, there are a number of researchers and institutions looking at the concept of ‘learning spaces’, that is, the physical environment in which students and pupils might learn, such as classrooms, libraries and lecture theatres (Bligh and Crook 2016; Boys 2011; Pearshouse *et al.* 2009). A key component of future personalised learning may include 24-hr access to such spaces (Hartley 2009), which could help learners personalise when, where and how they engage in learning opportunities. This supports a ‘seamless learning’ approach (Sharples *et al.* 2012) where learners can experience continuity across, for example, location, time and technological settings. Future developments in this field include blending digital and physical spaces, sometimes referred to as ‘hybrid personal learning environments’ (Caldwell, Bilandzic, and Foth 2012), ‘smart environments’ or ‘smart laboratories’ (Lei *et al.* 2013). Some of these smart environments focus less on the integration with learning but rather more on conditions under which learning can be supported to learners with different goals or approaches to study. As such, they support a wider personalisation agenda by providing conditions under which learners can be supported to learn through seamless contexts. However, these can have cost, resourcing and health and safety implications, particularly for buildings that support 24-hr access, and often have to be considered as part of a broader service agreement by non-teaching staff, for example, estates and/or security teams.

Such support must also be cost-effective and provide flexible solutions to accommodate a variety of different learner strategies and motivations. The use of ‘smart systems’ that help act as digital ‘sixth sense’ may also have a role to play, in providing context-aware and context-sensitive resources based on what is available and relevant to the needs or motivations of the learner (Dede 2014), possibly taking into account the learners’ emotional states too.

However, we also need to take into account how much – and what type of – control is given to the learner, and what should be retained by the teacher or educator (U.S. Department of Education Office of Educational Technology 2010). One suggestion is that learners could progress from a starting point of being ‘personalised for’ (customisation by e.g. a teacher) and move towards a position of greater autonomy and learner agency (‘personalising by’), where learners exercise choices to meet their own needs (de Freitas and Yapp 2005). However, it has been noted by Kucirkova and Cremin (2017) that agency in personalised learning is very closely related to the learners’ age.

Some stakeholders may wish to consider how to personalise learning within their own contexts. A helpful framework of analysis, for assessing TEL tools, is provided by Holmes *et al.* (2018). Like the authors of this paper, they strongly advocate an evidence-based approach but also recognise that many factors may be pertinent in terms of choosing and implementing particular tools and that, ultimately, the principal concern should be the learning that is to take place.

Conclusion

The work reported in this paper is the first in the field to combine a comprehensive review of the literature relating to personalised TEL, with a conceptualisation of what the benefits are (RQ1), how to enact it and how it leads to effective learning from the individual through to institutional levels (RQ2). It provides a critical synthesis and grounding for those wishing to deploy personalised TEL for their

own practices and moves forward our understanding by linking technological solutions and approaches with issues of quality enhancement, student satisfaction and retention.

However, as more multinational companies and venture capitalists invest in this area, there is a need for ongoing evidence-informed research and design into both policy and practice in order to ensure that the best decisions are made to empower our learners and to ensure that personalised learning focuses on *personal choice* and *personal control*.

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